

1AP20 Rec'd OCT 16 16 FEB 2006

THREADED CONNECTION FOR EXPANDABLE TUBULARS

Cross Reference To Related Applications

[0001] The present application is the National Stage patent application for PCT patent application serial number PCT/US2004/028438, attorney docket number 25791.137.02, filed on 9/1/2004, which claimed the benefit of the filing dates of the filing date of U.S. provisional patent application serial number 60/499,528, attorney docket number 25791.137, filed on September 2, 2003, the disclosure of which is incorporated herein by reference.

[0002] This application is a continuation-in-part of U.S. utility patent application serial no. 10/528222, attorney docket no. 25791.129.03, filed on 8/18/2005, which was the National Stage patent application for PCT application serial number PCT/US2003/025716, attorney docket number 25791.129.02, filed on 8/18/2003, which was a continuation-in-part of U.S. utility patent application serial number 10/528223, attorney docket number 25791.127.03, filed on 3/18/2005, which is a National Stage patent application of PCT application serial number PCT/US2003/025707, attorney docket number 25791.127.02, filed on 8/18/2003, which was a continuation-in-part of U.S. utility patent application serial number 10/525402, attorney docket number 25791.120.05, filed on 2/23/2005, which is a National Stage patent application of PCT application serial number PCT/US2003/025676, attorney docket number 25791.120.02, filed on 8/18/2003, which was a continuation-in-part of U.S. utility patent application serial number 10/525332, attorney docket number 25791.119.03, filed on 7/5/2005, which is a National Stage patent application of PCT application serial number PCT/US2003/025677, attorney docket number 25791.119.02, filed on 8/18/2003, which was a continuation-in-part of U.S. utility patent application serial number 10/522039, attorney docket number 25791.106.05, filed on 1/19/2005, which is a National Stage patent application of PCT application serial number PCT/US2003/019993, attorney docket number 25791.106.02, filed on 6/24/2003, which was a continuation-in-part of U.S. utility patent application serial number 10/511,410, attorney docket number 25791.101.05 PCT, which is a National Stage patent application of application serial number PCT/US2003/010144, attorney docket number 25791.101.02, filed on 3/31/2003, which was a continuation-in-part of, U.S. utility patent application serial number 10/510,966, attorney docket number 25791.93.05, filed on 10/12/2004 which is a National Stage patent application of PCT application serial number US2003/006544, attorney docket number 25791.93.02, filed on 3/04/2003, which was a continuation-in-part of PCT application serial number PCT/US2002/039418, attorney docket number 25791.92.02, filed on 12/10/2002.

[0003] This application is related to the following co-pending applications: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney

docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorneydocket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorneydocket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent application serial no. 09/523,468, attorneydocket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorneydocket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorneydocket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorneydocket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorneydocket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorneydocket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorneydocket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorneydocket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorneydocket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, fled on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no.

60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, filed on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorney docket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no. 60/221,443, attorney docket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, filed on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from provisional patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, filed on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026, filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent

Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorney docket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorney docket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorney docket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorney docket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorney docket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorney docket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorney docket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no.

60/343,674 , attorney docket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorney docket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorney docket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372 , attorney docket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703, attorney docket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorney docket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02,

which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application serial no.

60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) PCT application US 03/06544, filed on 3/4/03, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorneydocket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorneydocket no. 25791.94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorneydocket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorneydocket no. 25791.95, filed on 3/13/02, (70) U.S. patent application serial no. 10/261,927, attorney docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorneydocket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attorneydocket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorneydocket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorneydocket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application serial no. 60/372,632, attorneydocket no. 25791.101, filed on 4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorneydocket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorneydocket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791.107.02, which claims priority from U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from

U.S. provisional patent application serial no. 60/387,961, attorneydocket no. 25791.108, filed on 6/12/02, (80) PCT application US 03/20694, filed on 7/1/03, attorneydocket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorneydocket no. 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorneydocket no. 25791.111.02, which claims priority from U.S. provisional patent application serial no. 60/399,240, attorneydocket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no. 60/412,487, attorneydocket no. 25791.112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 60/412,488, attorneydocket no. 25791.114, filed on 9/20/02, (84) U.S. patent application serial no. 10/280,356, attorneydocket no. 25791.115, filed on 10/25/02, which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorneydocket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorneydocket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (85) U.S. provisional patent application serial no. 60/412,177, attorneydocket no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 60/412,653, attorneydocket no. 25791.118, filed on 9/20/02, (87) U.S. provisional patent application serial no. 60/405,610, attorneydocket no. 25791.119, filed on 8/23/02, (88) U.S. provisional patent application serial no. 60/405,394, attorneydocket no. 25791.120, filed on 8/23/02, (89) U.S. provisional patent application serial no. 60/412,544, attorneydocket no. 25791.121, filed on 9/20/02, (90) PCT application US 03/24779, filed on 8/8/03, attorneydocket no. 25791.125.02, which claims priority from U.S. provisional patent application serial no. 60/407,442, attorneydocket no. 25791.125, filed on 8/30/02, (91) U.S. provisional patent application serial no. 60/423,363, attorneydocket no. 25791.126, filed on 12/10/02, (92) U.S. provisional patent application serial no. 60/412,196, attorneydocket no. 25791.127, filed on 9/20/02, (93) U.S. provisional patent application serial no. 60/412,187, attorneydocket no. 25791.128, filed on 9/20/02, (94) U.S. provisional patent application serial no. 60/412,371, attorneydocket no. 25791.129, filed on 9/20/02, (95) U.S. patent application serial no. 10/382,325, attorneydocket no. 25791.145, filed on 3/5/03, which is a continuation of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorneydocket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (96) U.S. patent application serial no. 10/624,842, attorneydocket no. 25791.151, filed on 7/22/03, which is a divisional of U.S. patent application serial no. 09/502,350, attorneydocket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (97) U.S. provisional patent application serial no. 60/431,184, attorneydocket no. 25791.157, filed on 12/5/02, (98) U.S. provisional patent application serial no. 60/448,526, attorneydocket no.

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Background

[0004] This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration.

[0005] Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole

interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of a smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in a downward direction. Cement annuli may be provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

[0006] During oil exploration, a wellbore typically traverses a number of zones within a subterranean formation. Wellbore casings are then formed in the wellbore by radially expanding and plastically deforming tubular members that are coupled to one another by threaded connections. The threaded engagement between properly secured tubular members in a conventional casing joint is effective in maintaining a secure mechanical connection that holds the string together and effectively seals the internal casing area from the formation wellbore environment. When the casing string and connection are enlarged radially, a conventional connection changes dimensionally in a way that can prevent the engaged components of the connection from properly engaging and sealing. The radial expansion of a conventional connection may weaken or otherwise damage the connection sufficiently to permit mechanical separation or leakage in the connection.

[0007] The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming and/or repairing threaded wellbore casings.

Summary

[0008] According to one embodiment, an assembly is provided that includes a first tubular member including external threads, and a second tubular member comprising internal threads coupled to the external threads of the first tubular member. At least one of the first and second tubular members define one or more stress concentrators.

[0009] According to another embodiment, a method for forming a wellbore casing has been described that includes positioning any one, portion, or combination, of the embodiments of the assemblies disclosed herein within a borehole that traverses a subterranean formation, and radially expanding and plastically deforming the assembly within the borehole.

[00010] According to another embodiment, an apparatus is provided that includes a wellbore that traverses a subterranean formation, and a wellbore casing positioned within

and coupled to the wellbore. The wellbore casing is coupled to the wellbore by a process including: positioning any one, portion, or combination, of the assemblies disclosed herein within the wellbore, and radially expanding and plastically deforming the assembly within the wellbore.

[00011] According to another embodiment, a system for forming a wellbore casing is provided that includes means for positioning any one, portion, or combination, of the assemblies disclosed herein within a borehole that traverses a subterranean formation, and means for radially expanding and plastically deforming the assembly within the borehole.

[00012] According to another embodiment, a method of providing a fluid tight seal between a pair of overlapping tubular members is provided that includes forming one or more stress concentrators within at least one of the tubular members, and radially expanding and plastically deforming the tubular members.

Brief Description of the Drawings

[00013] Fig. 1 illustrates a system for radially expanding a tubular member that includes a tubular assembly having first and second tubulars that are threadably coupled.

[00014] Fig. 2a is a cross-sectional illustration of the tubular assembly of the system of Fig. 1.

[00015] Fig. 2b is a front view of the tubular assembly of Fig. 2a.

[00016] Figs. 3 is a graphical illustration of the pressure integrity of the threaded connection of the tubular assembly of Figs. 2a and 2b before, during, and after being radially expanded and plastically deformed using the system of Fig. 1.

[00017] Fig. 4 is a cross-sectional illustration of an alternative embodiment of the tubular assembly of Fig. 2a.

[00018] Fig. 5 is a cross-sectional illustration of another alternative embodiment of the tubular assembly of Fig. 2a.

[00019] Fig. 6a is a cross-sectional illustration of another alternative embodiment of the tubular assembly of Fig. 2a.

[00020] Fig. 6b is a front view of the tubular assembly of Fig. 6a.

Detailed Description of the Illustrative Embodiments

[00021] Referring initially to Fig. 1, a wellbore 10 that traverses a subterranean formation 12 includes a tubular assembly 14 positioned therein. The tubular assembly 14 includes a first tubular 16 threadably coupled to a second tubular 18 by a conventional threaded connection 20. In order to radially expand and plastically deform the tubular assembly 14, a conventional expansion device 22 coupled to a conventional support member

24 is displaced relative to the tubular assembly in a longitudinal direction. As will be recognized by persons having ordinary skill in the art, the threaded connection 20 includes external threads formed on an exterior surface of an end portion of the first tubular 16 and mating internal threads formed on an internal surface of an end portion of the second tubular 18.

[00022] As illustrated in Figs. 2a and 2b, in an exemplary embodiment, a spiral groove 26 is defined in the exterior surface of the second tubular 18 proximate and in opposing relation to at least a portion of the threaded connection 20. In this manner, the spiral groove 26 provides a stress concentration element that, during the radial expansion and plastic deformation of the tubular assembly 14 by the expansion device 22, enhances and concentrates the forces applied to the mating threads of the threaded connection 20. As a result, a fluid tight connection is provided within the threaded connection 20 following the radial expansion and plastic deformation of the threaded connection.

[00023] Referring now to Fig. 3, during an exemplary experimental test of the tubular assembly 14, the first and second tubulars, 16 and 18, were threadably coupled, and then radially expanded and plastically deformed using the expansion device 22. Throughout the experimental test, the interior of the tubular assembly 14 was pressurized using a fluidic materials and the corresponding operating pressure (PSIG) within the tubular assembly 14 was monitored.

[00024] In particular, following the threaded coupling of the first and second tubulars, 16 and 18, the tubular assembly 14 was pressurized using a fluidic material as indicated by the portion A of Fig. 3 and was able to contain a fluid pressure of about 2000 psi for at least about 30 minutes as indicated by the portion B of Fig. 3. Thus, before radial expansion and plastic deformation, the threaded connection 20 was capable of withstanding approximately 2000 psi as illustrated by the portion B of Fig. 3.

[00025] The radial expansion of the threaded connection 20 was then begun using the expansion device 22 which initially caused an elastic expansion of the threaded connection. As the stress in the threaded connection 20 increased, the sealing capacity of the threaded connection increased to about 3000 psi as illustrated by the portion C of Fig. 3. Thus, the additional stress allowed the stress concentration elements to create zones of increased stress which increased the sealing capability of the threaded connection 20.

[00026] During continued operation of the expansion device 22, the stress in the threaded connection 20 remained relatively constant as further expansion caused the stress in the threaded connection 20 to move from the elastic to the plastic range as illustrated by the portion D of Fig. 3 during which the sealing capacity of the threaded connection remained at about 3000 psi.

[00027] Further operation of the expansion device 22 caused the stress in the threaded connection 20 to increase as the stress approached the yield stress. This additional increase in stress, caused an additional increase in the sealing capacity of the threaded connection to about 4000 psi as illustrated by the portion E of Fig. 3. Further operation of the expansion device 22 caused a failure of the connection and a drop in the operating pressure as indicated by the portion F of Fig. 3.

[00028] As illustrated in Fig. 3, during the exemplary experimental test of the tubular assembly 14, the sealing capacity of the threaded connection 20 increased significantly after being radially expanded. This was an unexpected result.

[00029] Referring now to Fig. 4, in an alternative embodiment, a spiral groove 28 is defined in the interior surface of the first tubular 16 proximate and in opposing relation to at least a portion of the threaded connection 20. In this manner, the spiral grooves, 26 and 28, provide stress concentration elements that, during the radial expansion and plastic deformation of the tubular assembly 14 by the expansion device 22, enhance and concentrates the forces applied to the mating threads of the threaded connection 20. As a result, a fluid tight connection is provided within the threaded connection 20 following the radial expansion and plastic deformation of the threaded connection.

[00030] Referring now to Fig. 5, in an alternative embodiment, the threaded connection 20 includes at least one portion 20a that is not threaded. In this manner, the spiral grooves, 26 and 28, provide stress concentration elements that, during the radial expansion and plastic deformation of the tubular assembly 14 by the expansion device 22, enhance and concentrates the forces applied to the mating threads of the threaded portions of the threaded connection 20. Furthermore, the addition of the non threaded portion 20a to the threaded connection 20 further enhances the stress concentration effect of the spiral grooves, 26 and 28. As a result, a fluid tight connection is provided within the threaded connection 20 following the radial expansion and plastic deformation of the threaded connection.

[00031] Referring now to Figs. 6a and 6b, in an alternative embodiment, the threaded connection 20 includes a connector sleeve 30 that receives and mates with the ends of the first and second tubulars, 16 and 18, and includes an internal flange 30a that is received within and mates with an annulus 16a defined within the exterior surface of the first tubular 16 proximate an end face of the second tubular 18. The connector sleeve 30 further defines a plurality of circumferentially spaced apart longitudinal slots 30b that intersect one or more of the spiral grooves 26. In this manner, the spiral grooves 26 and the slots 30b provide stress concentration elements that, during the radial expansion and plastic deformation of the tubular assembly 14 by the expansion device 22, enhance and concentrates the forces applied to the mating threads of the threaded portions of the threaded connection 20. As a

result, a fluid tight connection is provided within the threaded connection 20 following the radial expansion and plastic deformation of the threaded connection.

[00032] In one embodiment, the system 10 may be used to radially expand and plastically deform the tubular members, 16 and 18, by displacing the expansion device 22 in longitudinal direction in a conventional manner and/or by rotating the expansion device relative to tubular members in a conventional manner and/or by expanding the size of the expansion device in a conventional manner within the tubular members. In several alternative embodiments, the expansion device 22 is, or includes, one or more of the conventional commercially available expansion devices available from Enventure Global Technology L.L.C., Weatherford International, Baker Hughes, Schlumberger, and/or Halliburton Energy Services.

[00033] The operation and design of the embodiments described above with reference to Figs. 1, 2a, 2b, 3, 4, 5, 6a, and 6b may also be implemented using one or more of the apparatus and methods as disclosed in one or more of the following: (1) U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorneydocket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, which claims priority from provisional application 60/121,702, filed on 2/25/99, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (4) U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorneydocket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (5) U.S. patent application serial no. 10/169,434, attorneydocket no. 25791.10.04, filed on 7/1/02, which claims priority from provisional application 60/183,546, filed on 2/18/00, (6) U.S. patent application serial no. 09/523,468, attorneydocket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (7) U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (8) U.S. patent number 6,575,240, which was filed as patent application serial no. 09/511,941, attorneydocket no. 25791.16.02, filed on 2/24/2000, which claims priority from provisional application 60/121,907, filed on 2/26/99, (9) U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (10) U.S. patent application serial no. 09/981,916, attorney docket no. 25791.18, filed on 10/18/01 as a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney

docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (11) U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorneydocket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (12) U.S. patent application serial no. 10/030,593, attorneydocket no. 25791.25.08, filed on 1/8/02, which claims priority from provisional application 60/146,203, filed on 7/29/99, (13) U.S. provisional patent application serial no. 60/143,039, attorneydocket no. 25791.26, filed on 7/9/99, (14) U.S. patent application serial no. 10/111,982, attorneydocket no. 25791.27.08, filed on 4/30/02, which claims priority from provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (15) U.S. provisional patent application serial no. 60/154,047, attorneydocket no. 25791.29, filed on 9/16/1999, (16) U.S. provisional patent application serial no. 60/438,828, attorneydocket no. 25791.31, filed on 1/9/03, (17) U.S. patent number 6,564,875, which was filed as application serial no. 09/679,907, attorney docket no. 25791.34.02, on 10/5/00, which claims priority from provisional patent application serial no. 60/159,082, attorneydocket no. 25791.34, filed on 10/12/1999, (18) U.S. patent application serial no. 10/089,419, filed on 3/27/02, attorney docket no. 25791.36.03, which claims priority from provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed on 10/12/1999, (19) U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorneydocket no. 25791.37, filed on 10/12/1999, (20) U.S. patent application serial no. 10/303,992, fled on 11/22/02, attorney docket no. 25791.38.07, which claims priority from provisional patent application serial no. 60/212,359, attorneydocket no. 25791.38, filed on 6/19/2000, (21) U.S. provisional patent application serial no. 60/165,228, attorneydocket no. 25791.39, filed on 11/12/1999, (22) U.S. provisional patent application serial no. 60/455,051, attorneydocket no. 25791.40, filed on 3/14/03, (23) PCT application US02/2477, filed on 6/26/02, attorney docket no. 25791.44.02, which claims priority from U.S. provisional patent application serial no. 60/303,711, attorney docket no. 25791.44, filed on 7/6/01, (24) U.S. patent application serial no. 10/311,412, filed on 12/12/02, attorney docket no. 25791.45.07, which claims priority from provisional patent application serial no. 60/221,443, attorneydocket no. 25791.45, filed on 7/28/2000, (25) U.S. patent application serial no. 10/, fled on 12/18/02, attorney docket no. 25791.46.07, which claims priority from provisional patent application serial no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (26) U.S. patent application serial no. 10/322,947, filed on 1/22/03, attorney docket no. 25791.47.03, which claims priority from provisional patent application serial no. 60/233,638, attorneydocket no. 25791.47, filed on 9/18/2000, (27) U.S. patent application serial no. 10/406,648, fled on 3/31/03, attorney docket no. 25791.48.06, which claims priority from provisional patent

application serial no. 60/237,334, attorney docket no. 25791.48, filed on 10/2/2000, (28) PCT application US02/04353, filed on 2/14/02, attorney docket no. 25791.50.02, which claims priority from U.S. provisional patent application serial no. 60/270,007, attorney docket no. 25791.50, filed on 2/20/2001, (29) U.S. patent application serial no. 10/465,835, filed on 6/13/03, attorney docket no. 25791.51.06, which claims priority from provisional patent application serial no. 60/262,434, attorney docket no. 25791.51, filed on 1/17/2001, (30) U.S. patent application serial no. 10/465,831, filed on 6/13/03, attorney docket no. 25791.52.06, which claims priority from U.S. provisional patent application serial no. 60/259,486, attorney docket no. 25791.52, filed on 1/3/2001, (31) U.S. provisional patent application serial no. 60/452,303, filed on 3/5/03, attorney docket no. 25791.53, (32) U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (33) U.S. patent number 6,561,227, which was filed as patent application serial number 09/852,026, filed on 5/9/01, attorney docket no. 25791.56, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (34) U.S. patent application serial number 09/852,027, filed on 5/9/01, attorney docket no. 25791.57, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (35) PCT Application US02/25608, attorney docket no. 25791.58.02, filed on 8/13/02, which claims priority from provisional application 60/318,021, filed on 9/7/01, attorney docket no. 25791.58, (36) PCT Application US02/24399, attorney docket no. 25791.59.02, filed on 8/1/02, which claims priority from U.S. provisional patent application serial no. 60/313,453, attorney docket no. 25791.59, filed on 8/20/2001, (37) PCT Application US02/29856, attorney docket no. 25791.60.02, filed on 9/19/02, which claims priority from U.S. provisional patent application serial no. 60/326,886, attorney docket no. 25791.60, filed on 10/3/2001, (38) PCT Application US02/20256, attorney docket no. 25791.61.02, filed on 6/26/02, which claims priority from U.S. provisional patent application serial no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (39) U.S. patent application serial no. 09/962,469, filed on 9/25/01, attorney docket no. 25791.62, which is a divisional of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (40) U.S. patent application serial no. 09/962,470, filed on 9/25/01, attorney docket no. 25791.63, which is a divisional of U.S. patent

application serial no. 09/523,468, attorneydocket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (41) U.S. patent application serial no. 09/962,471, filed on 9/25/01, attorneydocket no. 25791.64, which is a divisional of U.S. patent application serial no. 09/523,468, attorneydocket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (42) U.S. patent application serial no. 09/962,467, filed on 9/25/01, attorneydocket no. 25791.65, which is a divisional of U.S. patent application serial no. 09/523,468, attorneydocket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (43) U.S. patent application serial no. 09/962,468, filed on 9/25/01, attorneydocket no. 25791.66, which is a divisional of U.S. patent application serial no. 09/523,468, attorneydocket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (44) PCT application US 02/25727, filed on 8/14/02, attorneydocket no. 25791.67.03, which claims priority from U.S. provisional patent application serial no. 60/317,985, attorneydocket no. 25791.67, filed on 9/6/2001, and U.S. provisional patent application serial no. 60/318,386, attorneydocket no. 25791.67.02, filed on 9/10/2001, (45) PCT application US 02/39425, filed on 12/10/02, attorneydocket no. 25791.68.02, which claims priority from U.S. provisional patent application serial no. 60/343,674, attorneydocket no. 25791.68, filed on 12/27/2001, (46) U.S. utility patent application serial no. 09/969,922, attorneydocket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorneydocket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (47) U.S. utility patent application serial no. 10/516,467, attorneydocket no. 25791.70, filed on 12/10/01, which is a continuation application of U.S. utility patent application serial no. 09/969,922, attorneydocket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorneydocket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, (48) PCT application US 03/00609, filed on 1/9/03, attorneydocket no. 25791.71.02, which claims priority from U.S. provisional patent application serial no. 60/357,372, attorneydocket no. 25791.71, filed on 2/15/02, (49) U.S. patent application serial no. 10/074,703, attorneydocket no. 25791.74, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorneydocket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (50) U.S. patent application serial no. 10/074,244, attorneydocket no. 25791.75, filed on 2/12/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorneydocket no. 25791.12.02, filed on 2/24/2000, which claims

priority from provisional application 60/121,841, filed on 2/26/99, (51) U.S. patent application serial no. 10/076,660, attorney docket no. 25791.76, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (52) U.S. patent application serial no. 10/076,661, attorney docket no. 25791.77, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (53) U.S. patent application serial no. 10/076,659, attorney docket no. 25791.78, filed on 2/15/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (54) U.S. patent application serial no. 10/078,928, attorney docket no. 25791.79, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (55) U.S. patent application serial no. 10/078,922, attorney docket no. 25791.80, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (56) U.S. patent application serial no. 10/078,921, attorney docket no. 25791.81, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (57) U.S. patent application serial no. 10/261,928, attorney docket no. 25791.82, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (58) U.S. patent application serial no. 10/079,276, attorney docket no. 25791.83, filed on 2/20/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (59) U.S. patent application serial no. 10/262,009, attorney docket no. 25791.84, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (60) U.S. patent application serial no. 10/092,481, attorney docket no. 25791.85, filed on 3/7/02, which is a divisional of U.S. patent number 6,568,471, which was filed as patent application serial no.

09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000, which claims priority from provisional application 60/121,841, filed on 2/26/99, (61) U.S. patent application serial no. 10/261,926, attorney docket no. 25791.86, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (62) PCT application US 02/36157, filed on 11/12/02, attorney docket no. 25791.87.02, which claims priority from U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/01, (63) PCT application US 02/36267, filed on 11/12/02, attorney docket no. 25791.88.02, which claims priority from U.S. provisional patent application serial no. 60/339,013, attorney docket no. 25791.88, filed on 11/12/01, (64) PCT application US 03/11765, filed on 4/16/03, attorney docket no. 25791.89.02, which claims priority from U.S. provisional patent application serial no. 60/383,917, attorney docket no. 25791.89, filed on 5/29/02, (65) PCT application US 03/15020, filed on 5/12/03, attorney docket no. 25791.90.02, which claims priority from U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/02, (66) PCT application US 02/39418, filed on 12/10/02, attorney docket no. 25791.92.02, which claims priority from U.S. provisional patent application serial no. 60/346,309, attorney docket no. 25791.92, filed on 1/7/02, (67) PCT application US 03/06544, filed on 3/4/03, attorney docket no. 25791.93.02, which claims priority from U.S. provisional patent application serial no. 60/372,048, attorney docket no. 25791.93, filed on 4/12/02, (68) U.S. patent application serial no. 10/331,718, attorney docket no. 25791.94, filed on 12/30/02, which is a divisional U.S. patent application serial no. 09/679,906, filed on 10/5/00, attorney docket no. 25791.37.02, which claims priority from provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (69) PCT application US 03/04837, filed on 2/29/03, attorney docket no. 25791.95.02, which claims priority from U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/02, (70) U.S. patent application serial no. 10/261,927, attorney docket no. 25791.97, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (71) U.S. patent application serial no. 10/262,008, attorney docket no. 25791.98, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (72) U.S. patent application serial no. 10/261,925, attorney docket no. 25791.99, filed on 10/1/02, which is a divisional of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from

provisional application 60/137,998, filed on 6/7/99, (73) U.S. patent application serial no. 10/199,524, attorney docket no. 25791.100, filed on 7/19/02, which is a continuation of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (74) PCT application US 03/10144, filed on 3/28/03, attorney docket no. 25791.101.02, which claims priority from U.S. provisional patent application serial no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/02, (75) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/02, (76) PCT application US 03/14153, filed on 5/6/03, attorney docket no. 25791.104.02, which claims priority from U.S. provisional patent application serial no. 60/380,147, attorney docket no. 25791.104, filed on 5/6/02, (77) PCT application US 03/19993, filed on 6/24/03, attorney docket no. 25791.106.02, which claims priority from U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/02, (78) PCT application US 03/13787, filed on 5/5/03, attorney docket no. 25791.107.02, which claims priority from U.S. provisional patent application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/02, (79) PCT application US 03/18530, filed on 6/11/03, attorney docket no. 25791.108.02, which claims priority from U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/02, (80) PCT application US 03/20694, filed on 7/1/03, attorney docket no. 25791.110.02, which claims priority from U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/02, (81) PCT application US 03/20870, filed on 7/2/03, attorney docket no. 25791.111.02, which claims priority from U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/02, (82) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.112, filed on 9/20/02, (83) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/02, (84) U.S. patent application serial no. 10/280,356, attorney docket no. 25791.115, filed on 10/25/02, which is a continuation of U.S. patent number 6,470,966, which was filed as patent application serial number 09/850,093, filed on 5/7/01, attorney docket no. 25791.55, as a divisional application of U.S. Patent Number 6,497,289, which was filed as U.S. Patent Application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, which claims priority from provisional application 60/111,293, filed on 12/7/98, (85) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/02, (86) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/02, (87) U.S. provisional patent application serial no. 60/405,610, attorney docket no. 25791.119, filed on 8/23/02, (88) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/02, (89) U.S. provisional patent application serial no. 60/412,544,

attorney docket no. 25791.121, filed on 9/20/02, (90) PCT application US 03/24779, filed on 8/8/03, attorney docket no. 25791.125.02, which claims priority from U.S. provisional patent application serial no. 60/407,442, attorneydocket no. 25791.125, filed on 8/30/02, (91) U.S. provisional patent application serial no. 60/423,363, attorneydocket no. 25791.126, filed on 12/10/02, (92) U.S. provisional patent application serial no. 60/412,196, attorneydocket no. 25791.127, filed on 9/20/02, (93) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/02, (94) U.S. provisional patent application serial no. 60/412,371, attorneydocket no. 25791.129, filed on 9/20/02, (95) U.S. patent application serial no. 10/382,325, attorneydocket no. 25791.145, filed on 3/5/03, which is a continuation of U.S. patent number 6,557,640, which was filed as patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, which claims priority from provisional application 60/137,998, filed on 6/7/99, (96) U.S. patent application serial no. 10/624,842, attorney docket no. 25791.151, filed on 7/22/03, which is a divisional of U.S. patent application serial no. 09/502,350, attorneydocket no. 25791.8.02, filed on 2/10/2000, which claims priority from provisional application 60/119,611, filed on 2/11/99, (97) U.S. provisional patent application serial no. 60/431,184, attorneydocket no. 25791.157, filed on 12/5/02, (98) U.S. provisional patent application serial no. 60/448,526, attorneydocket no. 25791.185, filed on 2/18/03, (99) U.S. provisional patent application serial no. 60/461,539, attorney docket no. 25791.186, filed on 4/9/03, (100) U.S. provisional patent application serial no. 60/462,750, attorneydocket no. 25791.193, filed on 4/14/03, (101) U.S. provisional patent application serial no. 60/436,106, attorneydocket no. 25791.200, filed on 12/23/02, (102) U.S. provisional patent application serial no. 60/442,942, attorneydocket no. 25791.213, filed on 1/27/03, (103) U.S. provisional patent application serial no. 60/442,938, attorney docket no. 25791.225, filed on 1/27/03, (104) U.S. provisional patent application serial no. 60/418,687, attorney docket no. 25791.228, filed on 4/18/03, (105) U.S. provisional patent application serial no. 60/454,896, attorneydocket no. 25791.236, filed on 3/14/03, (106) U.S. provisional patent application serial no. 60/450,504, attorneydocket no. 25791.238, filed on 2/26/03, (107) U.S. provisional patent application serial no. 60/451,152, attorney docket no. 25791.239, filed on 3/9/03, (108) U.S. provisional patent application serial no. 60/455,124, attorney docket no. 25791.241, filed on 3/17/03, (109) U.S. provisional patent application serial no. 60/453,678, attorneydocket no. 25791.253, filed on 3/11/03, (110) U.S. patent application serial no. 10/421,682, attorneydocket no. 25791.256, filed on 4/23/03, which is a continuation of U.S. patent application serial no. 09/523,468, attorney docket no. 25791.11.02, filed on 3/10/2000, which claims priority from provisional application 60/124,042, filed on 3/11/99, (111) U.S. provisional patent application serial no. 60/457,965, attorney docket no. 25791.260, filed on 3/27/03, (112) U.S. provisional patent application serial no. 60/455,718, attorneydocket no. 25791.262, filed on 3/18/03, (113) U.S. patent

number 6,550,821, which was filed as patent application serial no. 09/811,734, filed on 3/19/01, (114) U.S. patent application serial no. 10/436,467, attorneydocket no. 25791.268, filed on 5/12/03, which is a continuation of U.S. patent number 6,604,763, which was filed as application serial no. 09/559,122, attorneydocket no. 25791.23.02, filed on 4/26/2000, which claims priority from provisional application 60/131,106, filed on 4/26/99, (115) U.S. provisional patent application serial no. 60/459,776, attorneydocket no. 25791.270, filed on 4/2/03, (116) U.S. provisional patent application serial no. 60/461,094, attorneydocket no. 25791.272, filed on 4/8/03, (117) U.S. provisional patent application serial no. 60/461,038, attorney docket no. 25791.273, filed on 4/7/03, (118) U.S. provisional patent application serial no. 60/463,586, attorneydocket no. 25791.277, filed on 4/17/03, (119) U.S. provisional patent application serial no. 60/472,240, attorneydocket no. 25791.286, filed on 5/20/03, and (120) U.S. patent application serial no. 10/619,285, attorneydocket no. 25791.292, filed on 7/14/03, which is a continuation-in-part of U.S. utility patent application serial no. 09/969,922, attorney docket no. 25791.69, filed on 10/3/2001, which is a continuation-in-part application of U.S. patent no. 6,328,113, which was filed as U.S. Patent Application serial number 09/440,338, attorney docket number 25791.9.02, filed on 11/15/99, which claims priority from provisional application 60/108,558, filed on 11/16/98, the disclosures of which are herein incorporated by reference in their entirety.

[00034] In several alternative embodiments, the threaded connection 20 is a pin and box connection.

[00035] In several alternative embodiments, the cross sectional shape of the spiral grooves, 26 and 28, may, for example, be semi-circular, square, triangular, elliptical, or other shapes capable of providing a stress concentration element.

[00036] In several alternative embodiments, one or both of the spiral grooves, 26 and 28, are aligned with the first full point of full form internal threads of the threaded connection 20.

[00037] In several alternative embodiments, one or both of the spiral grooves, 26 and 28, form a helical spiral that may be left-handed or right-handed.

[00038] In several alternative embodiments, one or both of the spiral grooves, 26 and 28, correspond to the interior thread roots of the internal connecting threads of the threaded connection 20.

[00039] In several alternative embodiments, one or both of spiral grooves, 26 and 28, are axially aligned with and are radially offset from the internal connecting threads of the threaded connection 20.

[00040] In several alternative embodiments, a stress concentration element, for example, in the form of a plurality of grooves defined in the exterior surface of the second

tubular 18 proximate to the threaded connection 20 may be substituted for, or used in addition to, the spiral grooves 26.

[00041] In several alternative embodiments, a stress concentration element, for example, in the form of a plurality of circular or radial grooves defined in the exterior surface of the second tubular 18 proximate the threaded connection 20 may be substituted for, or used in addition to, the spiral grooves 26.

[00042] In several alternative embodiments, a stress concentration element, for example, in the form of longitudinal or axial grooves defined in the exterior surface of the second tubular 18 proximate the threaded connection 20 may be substituted for, or used in addition to, the spiral grooves 26.

[00043] In several alternative embodiments, a stress concentration element, for example, in the form of a plurality of parallel grooves defined in the exterior surface of the second tubular 18 proximate the threaded connection 20, intersecting an angle with a longitudinal axis of the second tubular between about 15 and about 75 degrees or between about 30 and 60 degrees may be substituted for, or used in addition to, the spiral grooves 26.

[00044] In several alternative embodiments, a stress concentration element, for example, in the form of a plurality of grooves defined in the interior surface of the first tubular 16 proximate to the threaded connection 20 may be substituted for, or used in addition to, the spiral grooves 28.

[00045] In several alternative embodiments, a stress concentration element, for example, in the form of a plurality of circular or radial grooves defined in the interior surface of the first tubular 16 proximate the threaded connection 20 may be substituted for, or used in addition to, the spiral grooves 28.

[00046] In several alternative embodiments, a stress concentration element, for example, in the form of longitudinal or axial grooves defined in the interior surface of the first tubular 16 proximate the threaded connection 20 may be substituted for, or used in addition to, the spiral grooves 28.

[00047] In several alternative embodiments, a stress concentration element, for example, in the form of a plurality of parallel grooves defined in the interior surface of the first tubular 16 proximate the threaded connection 20, intersecting an angle with a longitudinal axis of the first tubular between about 15 and about 75 degrees or between about 30 and 60 degrees may be substituted for, or used in addition to, the spiral grooves 28.

[00048] In an exemplary embodiment, the internal threads of the threaded connection 20 have a left handed orientation, a thread taper of 0.750 inches per foot, thread roots and thread crests that are parallel to the thread taper, and a thread pitch of 5 threads per inch, and the external threads of the threaded connection have a left handed orientation, a thread

taper of 0.750 inches per foot, thread roots and thread crests that are parallel to the thread taper, and a thread pitch of 5 threads per inch. In an exemplary embodiment, the internal and/or external threads of the threaded connection align with an axis of the threaded connection to within plus or minus about 0.5 degrees.

[00049] In several alternative embodiments, one or more of the spiral grooves, 26 and 28, are axially aligned with and radially offset from the thread root of the internal and or external threads of the threaded connection.

[00050] In several alternative embodiments, one or more of the spiral grooves, 26 and 28, are positioned in opposition to the thread roots of the internal and/or external threads of the threaded connection 20.

[00051] In several exemplary embodiments, the non-threaded portion 20a of the threaded connection 20 includes a plurality of stepped cylindrical portions defined to create a plurality of stepped concentric cylindrical surfaces in the non-threaded portion of the threaded connection.

[00052] In several exemplary embodiments, the non-threaded portion 20a of the threaded connection 20 includes a spiraled portion.

[00053] In several alternative embodiments, a stress concentration element such as, for example, grooves defined with the internal and/or external surfaces of the connector sleeve 30 may be substituted for, or used in addition to, the slots 30b.

[00054] In several alternative embodiments, the slots 30b of the connector sleeve 30 are aligned with the longitudinal axis of the tubular assembly 14.

[00055] In several alternative embodiments, the internal diameter of the connector sleeve 30 is at least approximately .020" greater than the exterior diameter of the second tubular 18. In this manner, during the threaded coupling of the first and second tubulars, 16 and 18, fluidic materials within the first and second tubulars may be vented from the members.

[00056] In several alternative embodiments, following the radial expansion and plastic deformation of the first and second tubulars, 16 and 18, and the connector sleeve 30, using the expansion device 22, the connector sleeve 30 is maintained in circumferential tension and the threadably coupled end portions of the first and second tubulars are maintained in circumferential compression.

[00057] In several alternative embodiments, the use of the connector sleeve 30 during (a) the coupling of the first tubular 16 to the second tubular 18, (b) the placement of the first and second tubulars within the wellbore 10, and (c) the radial expansion and plastic deformation of the tubular assembly 14 may provide a number of significant benefits. For example, connector sleeve 30 may protect the exterior surfaces of end portions of the first

and second tubulars, 16 and 18, during handling and insertion of the tubular members within the structure. In this manner, damage to the exterior surfaces of the end portions of the first and second tubulars, 16 and 18, is prevented that could result in stress concentrations that could result in a catastrophic failure during subsequent radial expansion operations. In addition, during the relative rotation of first and second tubulars, 16 and 18, required during the threaded coupling of the first and second tubulars, the connector sleeve 30 provides an indication as to what degree the first and second tubulars are threadably coupled. For example, if the connector sleeve 30 can be easily rotated, that would indicate that the first and second tubulars, 16 and 18, are not fully threadably coupled and in intimate contact with internal flange 30a of the connector sleeve 30. Furthermore, the connector sleeve 30 may prevent crack propagation during the radial expansion and plastic deformation of the tubular assembly 14. In this manner, failure modes such as, for example, longitudinal cracks in the end portions of the first and second tubulars, 16 and 18, be limited in severity or eliminated all together.

[00058] An assembly has been described that includes a first tubular member including external threads, a second tubular member including internal threads coupled to the external threads of the first tubular member, and at least one stress concentrator adapted to improve a seal between the first tubular member and the second tubular member. In an exemplary embodiment, the assembly further includes an external sleeve surrounding the first and second tubular members. In an exemplary embodiment, one or more of the stress concentrators include at least one surface of at least one of the first tubular member and the second tubular member. In an exemplary embodiment, the stress concentrator is defined axially adjacent to the internal threads of the second tubular member and external threads of the first tubular member. In an exemplary embodiment, the stress concentrator is defined radially offset from the internal threads of the second tubular member and external threads of the first tubular member.

[00059] An assembly has been described that includes a first tubular member including first threads on an external surface of the first tubular member, and a second tubular member including second threads on an internal surface of the second tubular member, wherein the first threads are adapted to threadingly engage with the second threads, and at least one stress concentrator. In an exemplary embodiment, the stress concentrator includes a groove defined on an exterior surface of the second tubular member. In an exemplary embodiment, the groove includes a helical groove. In an exemplary embodiment, the second threads include a pitch and a thread count, and the helical groove includes at least one of a pitch and a thread count substantially similar to the pitch and the thread count of the second threads. In an exemplary embodiment, the groove includes a plurality of radial grooves. In an exemplary embodiment, the stress concentrator includes a

plurality of axial grooves. In an exemplary embodiment, the stress concentrator includes a groove on an internal surface of the first tubular member. In an exemplary embodiment, the assembly further includes a sleeve exterior to the second tubular member, wherein the stress concentrator includes at least one of a groove and a notch in a surface of the sleeve.

[00060] A method has been described that includes connecting a first tubular member including external threads with a second tubular member including internal threads, providing at least one stress concentrator adapted to improve a seal between the first tubular member and the second tubular member, positioning the first tubular member and the second tubular member within a borehole that traverses a subterranean formation, and radially expanding and plastically deforming the first tubular member and the second tubular member within the borehole.

[00061] A method has been described that includes connecting a first tubular member including first threads on an external surface with a second tubular member including second threads on an internal surface, providing at least one stress concentrator, positioning the first tubular member and the second tubular member within a borehole that traverses a subterranean formation, and radially expanding and plastically deforming the first tubular member and the second tubular member within the borehole.

[00062] An apparatus has been described that includes a wellbore that traverses a subterranean formation, and a wellbore casing positioned within the wellbore, the wellbore casing including: a first tubular member including external threads, and a second tubular member including internal threads coupled to the external threads of the first tubular member, at least one stress concentrator adapted to improve a seal between the first tubular member and the second tubular member.

[00063] An apparatus has been described that includes a wellbore that traverses a subterranean formation, and a wellbore casing positioned within the wellbore, wherein the wellbore casing is positioned within the wellbore by a process including: connecting a first tubular member including external threads with a second tubular member including internal threads, providing at least one stress concentrator adapted to improve a seal between the first tubular member and the second tubular member, positioning the first tubular member and the second tubular member within the wellbore, and radially expanding and plastically deforming the first tubular member and the second tubular member within the wellbore.

[00064] An apparatus has been described that includes a first tubular member including external threads, a second tubular member including internal threads coupled to the external threads of the first tubular member, and a means to improve a seal between the first tubular member and the second tubular member following a radial expansion and plastic deformation of the first and second tubular members.

[00065] A method has been described that includes providing a first tubular member and a second tubular member, forming one or more stress concentrators within at least one of the first and the second tubular members, connecting the first tubular member including first threads on an external surface with the second tubular member including second threads on an internal surface, and radially expanding and plastically deforming the tubular members. In an exemplary embodiment, the tubular members are threadably coupled, and the stress concentrators are formed adjacent the threaded coupling. In an exemplary embodiment, the stress concentrators include surface grooves formed in at least one of the tubular members.

[00066] It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the teachings of the various embodiments may be used to provide a wellbore casing, a pipeline, or a structural support. Furthermore, the elements and teachings of the various embodiments may be combined in whole or in part in some or all of the other embodiments. For example, the connector sleeve may be omitted and/or one or more of the stress concentration grooves may be omitted. In addition, the stress concentration grooves may be provided in any geometric shape capable of concentrating stresses. Furthermore, stress concentration grooves may or may not be positioned in opposing relation to at least a portion of the threaded connection. In addition, the first and second tubulars, may or may not be threadably coupled to one another, and the threads of the threaded connection may be any type of threads.

[00067] Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.